ELASTIC DRAINAGE PAVEMENT COMPRISING WASTE POLYURETHANE CHIPS FOR USE ON EXISTING ROADS AND A PAVING METHOD USING THE SAME

FIELD OF THE INVENTION

The present invention relates to an elastic drainage pavement comprising waste-polyurethane chips for use on existing roads and a paving method using the same. This pavement uses a binder specially developed to secure the binding between an upper polyurethane chip layer and a lower existing pavement layer as well as the binding among the waste-polyurethane chips, resulting in excellent strength and durability, and uses recycled waste-polyurethane chips to provide elasticity and draining property suitable for sports activities, walking, outdoor exercises and the like.

BACKGROUND OF THE INVENTION

When a heavy rain falls on conventional existing asphalt or concrete pavement, the rain does not sink into the ground, but flows through roadside drainage system to river, stream, waste water treatment plant or public water area. However, in case of a localized torrential downpour for a short period of time or a heavy rain for a long period of time during the rainy season, the drained rain and water may overflow the river and stream, causing very dangerous and unstable situation. Also, as the rain and water cannot permeate into the conventional existing road or pavement, it obstructs safe passage and causes a lot of inconvenience to pedestrians.

Therefore, in order to overcome such disadvantages of the conventional asphalt or concrete pavement, a permeable concrete pavement comprising aggregates of

the size generally less than 13 mm to maintain suitable porosity and strength, and allowing water to seep into the ground through a surface layer and a base layer of the pavement has been suggested and used.

Specifically, the permeable concrete allows rain or water to seep into the ground through pores among the aggregates, fostering the growth of trees and plants, and also prevents flooding of the river by allowing heavy or torrential rain to flow under the earth. Further, as the rain or water does not stay on the permeable concrete pavement, it provides less slippery and much safer walking, jogging or driving conditions.

For these reasons, the permeable concrete pavement has come into use more widely, especially on trails at parks, bicycle paths, tracks for in-line skating, golf-course trails, etc.

Conventional permeable pavements are divided into permeable asphalt concrete and permeable cement concrete. However, the asphalt concrete has disadvantages in that the surface deforms considerably due to high temperatures during the summer season and the pores get clogged up due to the viscosity of the asphalt. Also, the cement concrete is so rigid that people get hurt when they fall on it.

In addition, the conventional permeable-concrete pavement is covered with epoxy pigments for cosmetic view of the surface, but a ramp covered with such epoxy pigments is more slippery than a normal concrete pavement, which causes problems in safety.

Further, because the surface of the concrete pavement is rugged, the surface can peel or break off, and when the pores are covered with dust, the pavement's permeability deteriorates, requiring additional maintenance costs for declogging the

pores, i.e. removal of the dust.

As an example to improve the disadvantages of the conventional permeable concrete, Korean Patent No. 404679 (patented on October 27, 2003 entitled "pavement using waste tire chips") discloses an elastic permeable pavement which comprises a land layer, a filter layer, a rubble layer, a permeable concrete layer, a waste-polyurethane chip layer, and a surface layer from the bottom to the top. Specifically, the filter layer is constructed by spreading small aggregates (sand), and the rubble layer is constructed by pouring and hardening concrete rubbles of the particle size 25mm or less onto the filter layer. The permeable concrete layer is made by blending aggregates of the particle size 5-13mm, cement and admixture products with water, and pouring this mixture on the rubble layer and curing it. As a result, the permeable concrete layer has the compressive strength of 100 kg/cm^2 or more and the permeability coefficient of $1x10^{-3}$ cm/sec or more. Further, the waste-tire chip layer is formed by pouring and spreading in the thickness of 10-20mm a mixture including waste-tire chips of particle size 2.5-7mm; a binder comprising 10-25g of urethane resin, epoxy resin or acrylic resin based on 100g of the waste tire chips; and 1-4g of an inorganic pigment on the same base. Furthermore, the surface layer is colored by spraying with the urethane resin, epoxy resin or acrylic resin on the waste-tire chip layer.

The elastic permeable pavement as disclosed in the above patent allows rain or water to penetrate into the ground, and the pavement is resistant to slipping and reduces diffused light-reflection resulted from the water staying on the pavement, thus securing safe passage of pedestrians and providing comfortable vision. Also, as using waste tires which have been one of the environmental pollutants, the pavement not only

absorbs impact on foot, but also contributes to the protection of environment and recycling of resources.

However, since the waste tire's smell of rubber lasted for a long time, the pavement using the waste tire could not provide a pleasant sense of smell. Further, since the urethane, epoxy and acrylic resin binders used in the above patent were those available in the market, there have been demands for a special binder which enhances the adhesive strength among pavement materials and maintains the strength and durability of the pavement for a long time.

Further, since the elastic permeable pavement in the above patent used a method of piling up the land layer, the filter layer, the rubble layer, the permeable concrete layer, the waste-polyurethane chip layer and the surface layer from the bottom, in a case where it was not necessary to dig open an existing pavement to newly pave it again, or in a case where there was no sufficient budget for such a pavement, such a pavement construction method of piling up the layers would not be economical in terms of process, time and cost.

Instead, although the existing pavement is not permeable, if it is covered with a permeable pavement so that the rain can pass through the permeable pavement and drain, it would not only be possible to prevent the overflow of the river or stream, but also be very economical since the existing pavement can be used as it is.

Therefore, the inventor of the present invention studied and researched into materials and binders for the elastic permeable pavement, and as a result, the inventor completed the present invention by using waste-polyurethane chips in place of waste-tire chips as a main component of the elastic pavement and developing a binder to secure the binding between an upper polyurethane-chip layer and a lower existing-

pavement layer as well as the binding among the waste-polyurethane chips.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an elastic drainage pavement, which uses waste-polyurethane chips obtained from soles of shoes, parts of toys, parts of refrigerators, parts of vehicles, and decrepit recycled-polyurethane resilient pavement to solve the smelling problem of waste tires, nurse resources and prevent environmental pollution, and which is elastic and permeable to provide comfort and shock absorption in walking as well.

Another object of the present invention is to provide an elastic drainage pavement and its paving method, which uses a binder specially developed to secure the binding between an upper waste-polyurethane chip layer and a lower existing-pavement layer as well as the binding among the waste-polyurethane chips, resulting in excellent strength and durability.

A further object of the present invention is to provide an elastic drainage pavement for use on existing roads and its paving method, which comprises forming a permeable waste-polyurethane chip layer on the existing pavement, to provide comfortable vision due to the reduction of diffused light-reflection caused by water staying on the pavement, and to provide safer walking, jogging or driving conditions, and also to prevent flooding of the river or stream due to heavy rain.

A further object of the present invention is to provide an elastic drainage pavement and its paving method, which is economical by using the existing pavement as it is.

In order to achieve the above objects, the elastic drainage pavement for use

on existing pavements according to the present invention comprises a primer layer which is spread on the existing pavement and comprises 10-20 % by weight of PPG (polypropylene glycol), 5-10 % by weight of TMP (trimethylol propane), 5-10 % by weight of 1,3-BG (1,3-butylene glycol), 15-25 % by weight of TDI (toluene diisocyanate), 49-64.9 % by weight of a solvent (xylene or methylethylketone), and 0.1-1.0 % by weight of an additive (defoaming agent); and an elastic drainage layer spread over the primer layer and prepared by mixing waste-polyurethane chips and a binder in the weight ratio of 3:1 to 4:1, the waste-polyurethane chips having the size of 1 to 5 mm and the binder comprising 50-70 % by weight of PPG, 5-10 % by weight of PBG (polybutadiene glycol), 3-5 % by weight of 1,3-BG, 20-30 % by weight of MDI (methylene diisocyanate) and 2-5 % by weight of TDI.

In addition, according to the present invention, a method of paving the elastic drainage pavement on existing pavement is provided, which comprises cleaning the existing pavement; paving it with a primer layer and then an elastic drainage layer, wherein the primer layer comprises 10-20 % by weight of PPG, 5-10 % by weight of TMP, 5-10 % by weight of 1,3-BG, 15-25 % by weight of TDI, 49-64.9 % by weight of a solvent (xylene or methylethylketone), and 0.1-1.0 % by weight of an additive (defoaming agent), and the elastic drainage layer is prepared by mixing waste-polyurethane chips and a binder in the weight ratio of 3:1 to 4:1 and pouring the mixture onto the primer layer in situ, the waste-polyurethane chips having the size of 1 to 5 mm and the binder comprising 50-70 % by weight of PPG, 5-10 % by weight of PBG, 3-5 % by weight of 1,3-BG, 20-30 % by weight of MDI and 2-5 % by weight of TDI; pressing with a roller of 20-30 kg heated to temperatures of 50-80°C and

trowelling the elastic drainage layer in the same temperature; and then curing for about 5 to 24 hours.

The waste-polyurethane chips used in the present invention are obtained by collecting waste-polyurethane scraps from soles of shoes, parts of toys, parts of refrigerators and vehicles, decrepit polyurethane resilient pavement, etc. and separating the scraps according to their colors; removing impurities attached on the scraps; pulverizing the waste-polyurethane scraps in a predetermined size; mixing the scraps with 0.3-1.0kg of stearic acid, 20-30kg of heavy calcium carbonate, 0.1-2.0kg of titanium dioxide as a decolorant and white pigment and 5kg or less of a pigment, based on 100kg of the pulverized waste-polyurethane scraps by stirring; heating and extruding the mixture; and then condensing and cutting the extruded mixture into a predetermined size.

In the present invention, a photoluminescent pigment, which emits light at night or darkness in case of rain by using the energy that has been accumulated during the daytime, can be used as the pigment, and zinc sulfide compounds can be used for this purpose. In this case, the amount of the photoluminescent pigment used is 20-40% by weight of the scraps.

For instance, waste-polyurethane chips made by using the photoluminescent pigment can be prepared separately from the chips made by using a normal pigment in a predetermined ratio, and they can be mixed with the binder respectively at a construction site, so that they can be distributed and spread in their respective positions that have been designed previously.

If a flame retarding property is required in preparing the waste-polyurethane chips, a flame retardant in the range of 1-2% by weight of the scraps can be added to the

mixture.

Further, depending on usages of the elastic drainage pavement, a foaming agent can be used to adjust the hardness of the waste-polyurethane chips. For example, the waste-polyurethane chips made by using a relatively large amount of the foaming agent can be used for sidewalks and trails, while the relatively hard polyurethane chips made by using less amount of the foaming agent can be used for bicycle paths and tracks for in-line skating.

The size of the waste-polyurethane chips can vary according to their usage, e.g., in 1-2mm, 2-3mm, 3-4mm, 1-5mm, etc. Smaller ones can be used for bicycle paths and tracks for in-line skating, and larger ones for sidewalks and trails. In particular, the polyurethane chips for trails may be formed in part or entirely in the shape of a strand having the length of 10-30mm and the thickness of 1-3mm, so that the chips can form large pores, providing more cushion and enhancing the permeability.

The waste-polyurethane chips in the elastic drainage layer can be replaced in part or entirely with new polyurethane chips. The new polyurethane chips are prepared by mixing 1 part by weight of liquid polyurethane with 0.5-1.2 parts by weight of heavy calcium carbonate, and 0.01 part by weight or less of a pigment or 0.1-0.4 parts by weight of a photoluminescent pigment by stirring; pouring the mixture into a mold and curing in a sheet form; and then cutting and pulverizing the polyurethane sheet into a predetermined size. The new polyurethane chips manufactured as such are very clear in color.

In addition, the binder used in the present invention is to secure the binding between the elastic drainage layer and the existing pavement and also among the waste-polyurethane chips in the elastic drainage layer. Usually, compounds having

molecular weight of 1,000-5,000 and having more than two hydroxy groups (-OH) or multi-functional isocyanate compounds (-NCO) are used as the binder.

For example, TDI and MDI are used as the chip binders. However, the adhesive property and the coefficient of expansion of the binders are variable depending on their molar ratio. Therefore, the inventor of the present invention developed a binder suitable for achieving the objects of the invention and having the elasticity and the coefficient of expansion similar to those of the polyurethane chips to provide an excellent adhesive property among the chips. This specially developed binder according to the present invention comprises 50-70 % by weight of PPG, 5-10 % by weight of PBG, 3-5 % by weight of 1,3-BG, 20-30 % by weight of MDI and 2-5 % by weight of TDI, wherein PPG is to provide toughness and 1,3-BG is used as a chain extender to form a polymer having higher molecular weight than a simple compound produced by the reaction between PPG and MDI. The binder of the present invention, therefore, does not only have a high adhesiveness and coefficient of expansion, but also has tensile strength and pliability from a primary reaction with MDI and a secondary reaction with TDI.

It is preferable that the polyurethane chips and the binder are blended in the weight ratio of 3:1 to 4:1. This is because use of the binder less than 20% by weight results in poor adhesive property, and use of more than 40% causes the pores to be clogged or the binder to be blown up during the curing step.

Further, the composition and the composition ratio of the primer layer are the optimum values that have been obtained by the inventor as a result of a long time research.

The elastic drainage pavement according to the present invention is

economical since it can be applied upon the existing street or pavement without scratching or digging out the existing pavement. It is only necessary to clean up the existing pavement by removing impurities therefrom, since the existence of such impurities may be an obstacle to the primer layer's adhering to the existing pavement. If the existing pavement is made up of tiles having smooth surface, it is preferable to use a strong epoxy or grind the surface before coating the primer layer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principal of the present invention will be described in more detail below with reference to the embodiments, but the scope of the invention is not limited within the embodiments.

1. Preparation of waste-polyurethane chips

As a preliminary step, waste-polyurethane scraps were collected from soles of shoes, parts of toys, parts of refrigerators and vehicles, decrepit polyurethane resilient pavement, etc., and separated according to their colors. From the separated waste-polyurethane scraps, impurities stuck thereto were removed by cutting.

Then, the waste-polyurethane scraps were pulverized in a crusher into the particle diameter of 3-30㎜, and transported to a mixer.

Based on 100kg of the pulverized waste-polyurethane scraps, 0.5kg of stearic acid, 25kg of heavy calcium carbonate, 0.2kg of titanium dioxide and 1.5kg of a pigment were added and mixed by stirring.

Then, the mixture was transported through a conveyor to an extruder where

the mixture was extruded in the form of a plate.

The extruded waste-polyurethane was passed to a second crusher and a cutter to be cut in the particle size of 1-5mm, resulting in the production of waste-polyurethane chips.

In this embodiment, if the flame retarding property is required, a flame retardant in the range of 1-2% by weight of the scraps can be added to the mixture.

2. Preparation of binder

30kg of PPG and 5kg of PBG were prepared as polyol compounds. Also, 13kg of MDI and 2kg of TDI as multi-functional isocyanate compounds and 2kg of 1,3-BG as a chain extender were prepared.

The above compounds were mixed with an accelerator and reacted to produce a binder having the following physical properties:

Physical property (unit)	**Result**
Blending ratio	1-part liquid
Solid in mixture (%)	97±3
Appearance	transparent light yellow
Viscosity (Cps/25°C)	2500±500
Specific gravity	1.00±0.10
Working life (min)	30±10
Time for curing (hr)	12±3
Coefficient of expansion (%)	100±50
Tensile strength (kg/cm^2)	10±5
Tear strength (kg/cm)	7±3

3. Site preparation

(1) The existing pavement was cleaned up and impurities thereon were removed.

(2) In order to pave the elastic drainage pavement on the existing tiles, the smooth surface of the tiles was grounded.

4. Primer layer

A primer composition prepared by mixing 5kg of PPG, 3kg of TMP, 2kg of 1,3-BG, 7kg of TDI, 17kg of xylene as a solvent and 0.3kg of a defoaming agent was spread on the existing pavement and the tiles as prepared above.

5. Elastic drainage pavement

[Embodiment 1]

100kg of the waste-polyurethane chips having the size of 1 to 3mm and 30kg of the binder were blended in situ.

This mixture was poured onto the primer layer which has been spread on the existing pavement or the tiles in the thickness of 10-20mm, and the spread mixture was pressed with a roller of 30 kg which has been heated to temperatures of about 80°C and trowelled at the same temperature.

Then, the pavement was cured for about 24 hours, during which the construction site was closed to traffic.

The elastic drainage pavement obtained as such had the strength and elasticity suitable for bicycle paths and tracks for in-line skating.

Change of pigments of the waste-polyurethane chips made it possible to

diversify the appearance of the elastic drainage pavement by having various colors and shapes.

[Embodiment 2]

In order to form an elastic drainage pavement suitable for walking, the waste-polyurethane chips having the size of 3 to 5mm on average and those having the length of 15mm and the thickness of 1 mm in a strand shape were prepared and respectively blended with the binder in the ratio of 3:1. The mixture was proceeded in the same manner as in Embodiment 1.

As a result, the elastic drainage pavement suitable for walking was obtained, and this pavement had pores larger than that produced in Embodiment 1 and was softer and more effective in drainage.

[Embodiment 3]

In this embodiment, the waste-polyurethane chips having the size of 3 to 5mm on average were prepared by using a normal pigment and the chips having the same size were separately prepared by using a photoluminescent pigment (zinc sulfide), each of which were then blended with the binder in the ratio of 3:1 in situ.

The waste-polyurethane chip mixture using the normal pigment was poured in the thickness of 10-20mm outside of a frame, e.g. a star shape frame, which has been preliminarily placed on the primer layer, and the waste-polyurethane chip mixture using the photoluminescent pigment was poured inside of the frame. Then, the both poured chips were pressed with a roller of 30 kg heated to temperatures of about 80°C and trowelled at the same temperature.

As a result, the elastic drainage pavement obtained on the existing pavement had the strength and optimum elasticity suitable for trails, and the pavement obtained on the existing tiles had the strength and elasticity suitable for walking and for other various usages.

Further, as the photoluminescent polyurethane chips could be disposed in various constellations, the chips emit light in the evening or at night (darkness), providing visual pleasure for pedestrians and helping students or children to study constellations.

[Embodiment 4]

50kg of the waste-polyurethane chips obtained from the above Embodiment 1 was used together with 50kg of polyurethane chips prepared by using new polyurethane material to be blended with the binder.

The urethane chips using the new polyurethane material were prepared by mixing 50kg of liquid polyurethane with 35kg of heavy calcium carbonate and 0.5kg of a pigment in a high-speed stirrer of more than 1000rpm, pouring and curing the mixture in a frame in the shape of a plate, and then pulverizing the cured mixture into the particle size of 3-5mm.

The other procedures were the same as in Embodiment 1, and as a result the elastic drainage pavement in much clearer color was obtained.

As described above, the elastic drainage pavement according to the present invention, which uses waste-polyurethane chips obtained from soles of shoes, parts of toys, parts of refrigerators and vehicles and decrepit recycled-polyurethane resilient

pavement, solves the smelling problem of waste tires, nurses resources and prevents environmental pollution. The drainage pavement is also elastic and permeable so that it can provide comfort and shock absorption in walking.

Further, according to the present invention, the elastic drainage pavement and its paving method use the binder specially developed to secure the binding between the polyurethane-chip layer and the existing-pavement layer as well as the binding among the waste-polyurethane chips, resulting in excellent strength and durability.

Furthermore, the elastic drainage pavement for use on existing roads according to the present invention, which comprises forming a permeable waste-polyurethane chip layer on the existing pavement, provides comfortable vision due to the reduction of diffused light-reflection resulted from the water staying on the pavement and provides safer walking, jogging or driving conditions. Also, the pavement prevents flooding of the river or stream due to heavy rain.

In addition, the present invention provides elastic drainage pavement and its paving method, which is economical by using the existing pavement as it is.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. The present invention covers the modifications and variations thereof provided they come within the scope of the appended claims and their equivalents.